

How can we make an isotropic HTS?

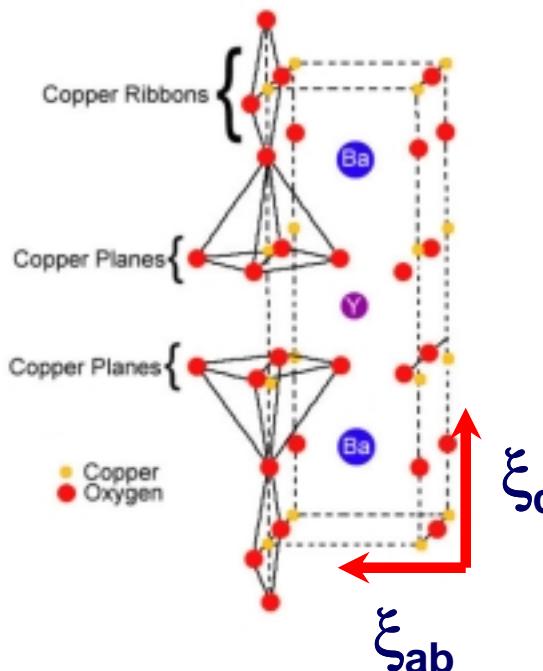
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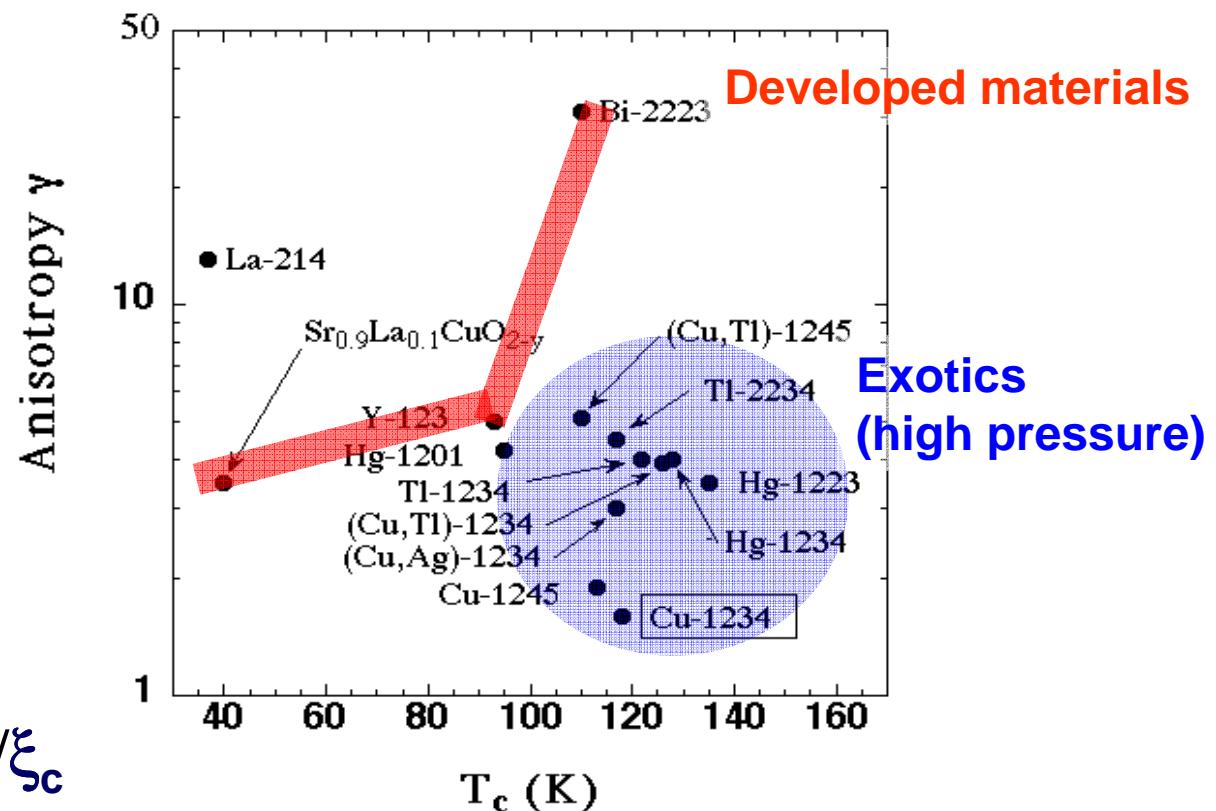
- **Why do we need isotropic HTS**
- **How we can determine effective mass anisotropy from transport properties**
- **Possibility of reducing anisotropy of YBCO material without T_c suppression**
- **Implications of these findings**

Anisotropy of HTS materials

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$$\gamma = (m_c/m_{ab})^{1/2} = \xi_{ab} / \xi_c$$



✓ High anisotropy is intrinsic to HTS

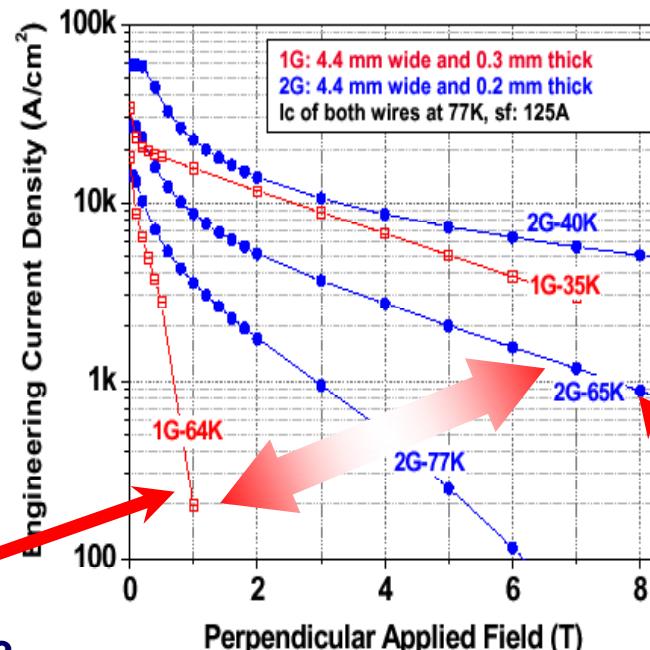
Why do we care about anisotropy? Practical implications of high anisotropy

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1G Wire: 125A, 4.4 mm width

2G Wire: 125A, 4.4 mm width

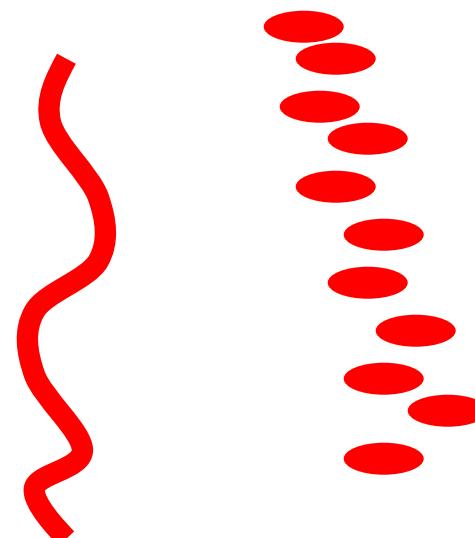


1G Bi-2223
 $T_c = 115 \text{ K}$, $\gamma = 50$

YBCO:
3D vortex line

Bi2223:
2D vortex disks

2G YBCO
 $T_c = 92 \text{ K}$, $\gamma = 5$



- ✓ High T_c of Bi-2223 came at too high a price of $\gamma \approx 50$

Why anisotropy is undesirable? Effect of thermal fluctuations

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- Importance of fluctuations is measured by the *Ginzburg number*:

$$Gi = \left[\frac{\gamma \cdot kT_c}{H_c^2(0)\xi^3(0)} \right]^2 \propto \gamma^2 \cdot T_c^4$$

anisotropy

Width of critical regime around T_c

$$\frac{\Delta T_c}{T_c} \sim Gi$$

Melting line (irreversibility line)

$$H_{irr} \propto \frac{H_{c2}(0)}{Gi}$$



DOE HTS Wire Development & Applications Workshop ★ January 16-17, 2007 ★ Panama City, FL

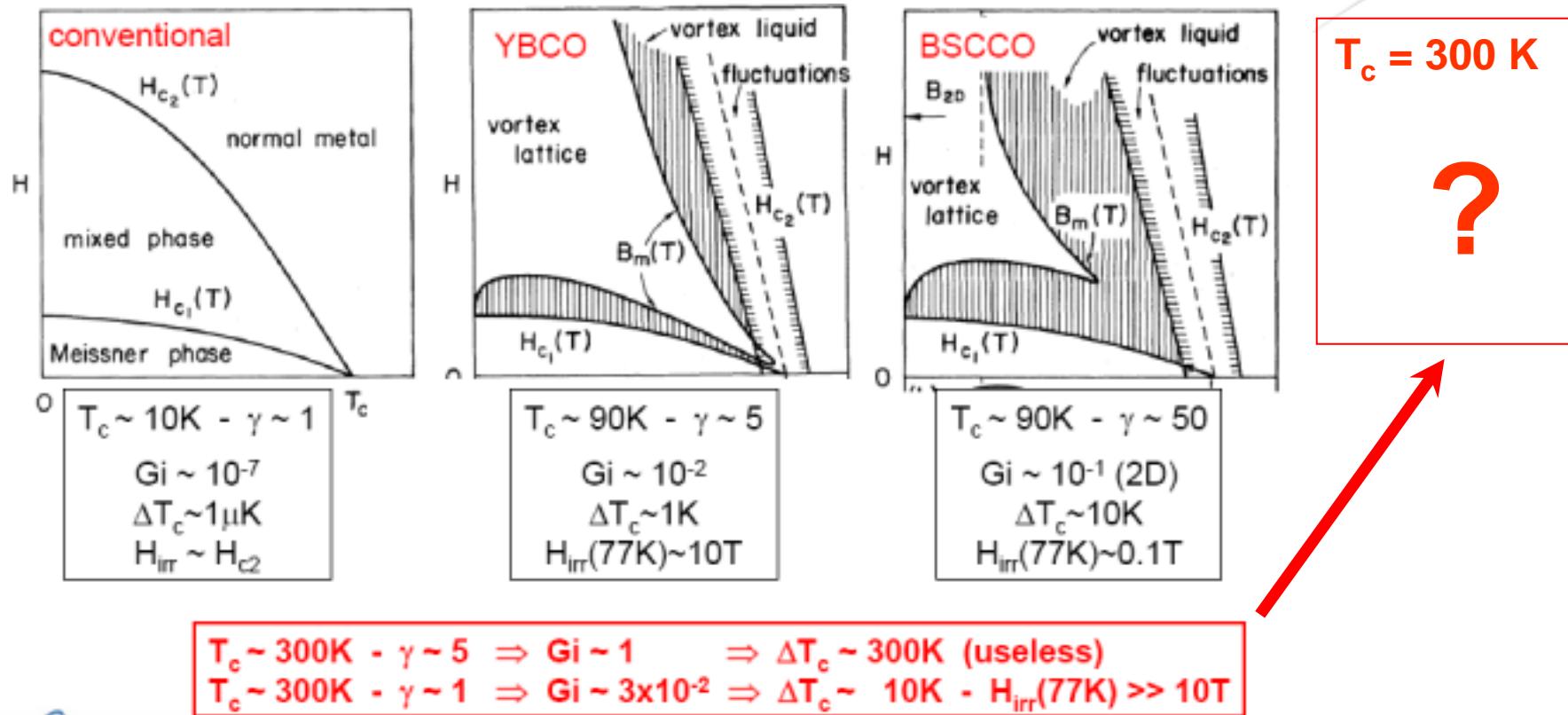


Adapted from Leonardo Civale presentation

✓ High anisotropy + high T_c = strong fluctuations

Thermal fluctuations and room-temperature superconductivity

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Adapted from Leonardo Civale presentation

- ✓ If we ever make a room temperature superconductor it'd better be an isotropic material with $\gamma \approx 1$

Experiment: How we determine γ

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PHYSICAL REVIEW LETTERS

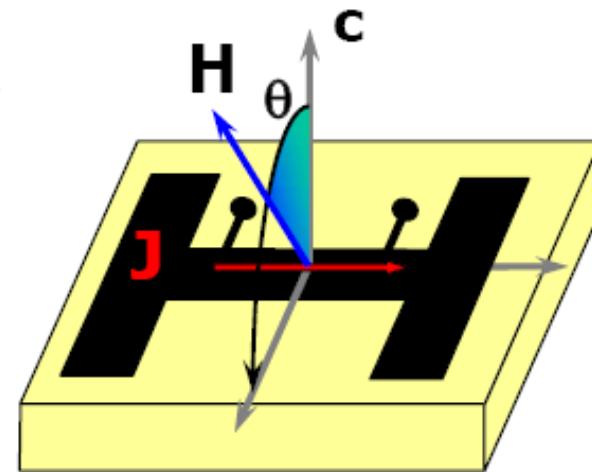
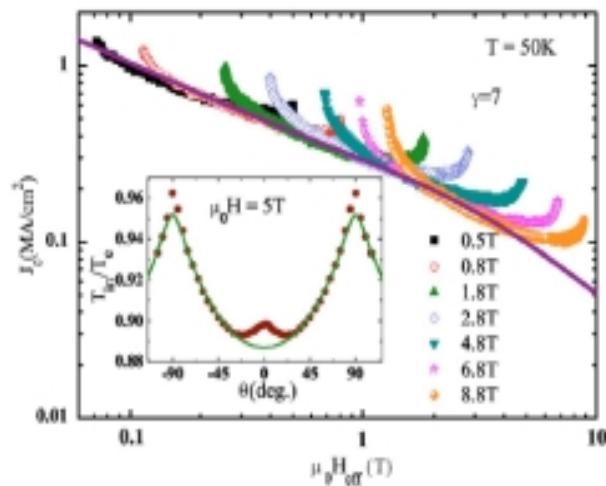
10 FEBRUARY 1992

From Isotropic to Anisotropic Superconductors: A Scaling Approach

G. Blatter,^{(1),(2)} V. B. Geshkenbein,^{(1),(3)} and A. I. Larkin^{(1),(3)}

Effective field scaling:

$$H_{\text{eff}} = H^* (\sin(\theta)^2 + \cos(\theta)^2 / \gamma^2)^{1/2}; \gamma = (m_{ab}/m_c)^{1/2}$$



Typical YBCO γ value 5 – 7
Puig et al. APL 2007

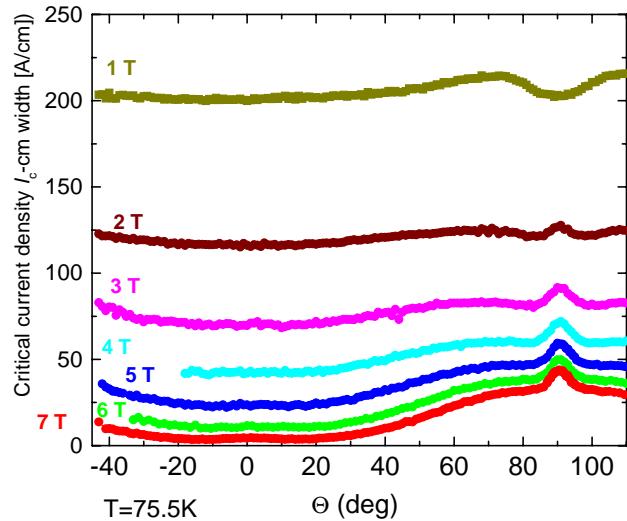
✓ Blatter scaling gives consistent γ value for wide variety of samples: from films to crystals

Breakthrough of 2006-2007: isotropic transport in epi-YBCO layers

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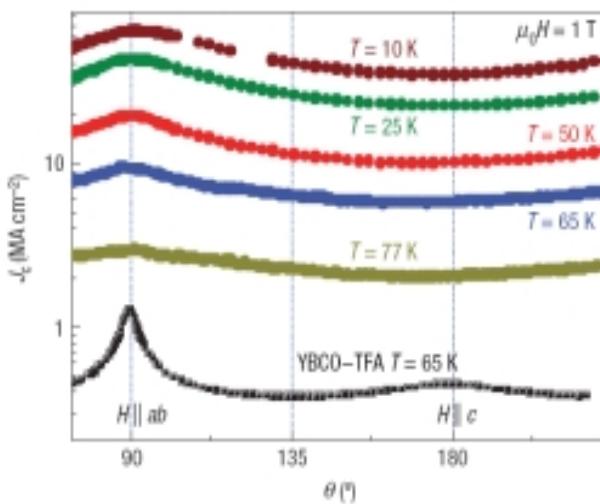
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Solid-solid growth, “isotropic” YBCO
Low-T growth
Doping BaZrO₃

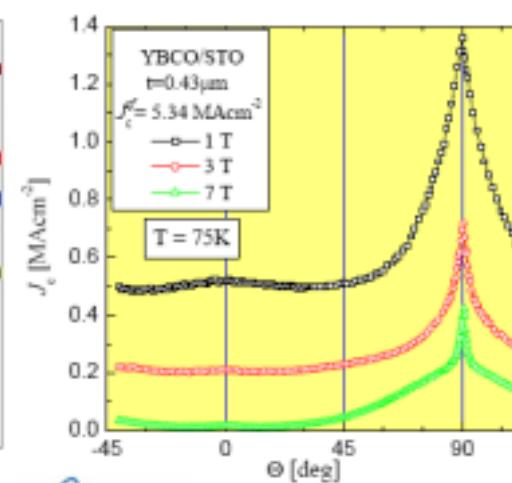


BNL, SST 2007

Vapor-solid growth
standard YBCO



Barcelona, Nat. Mat. 2007



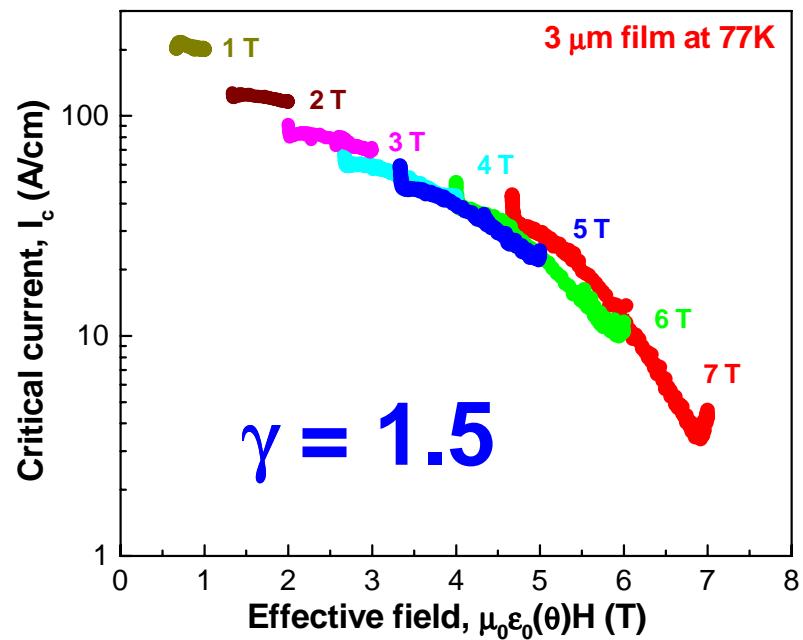
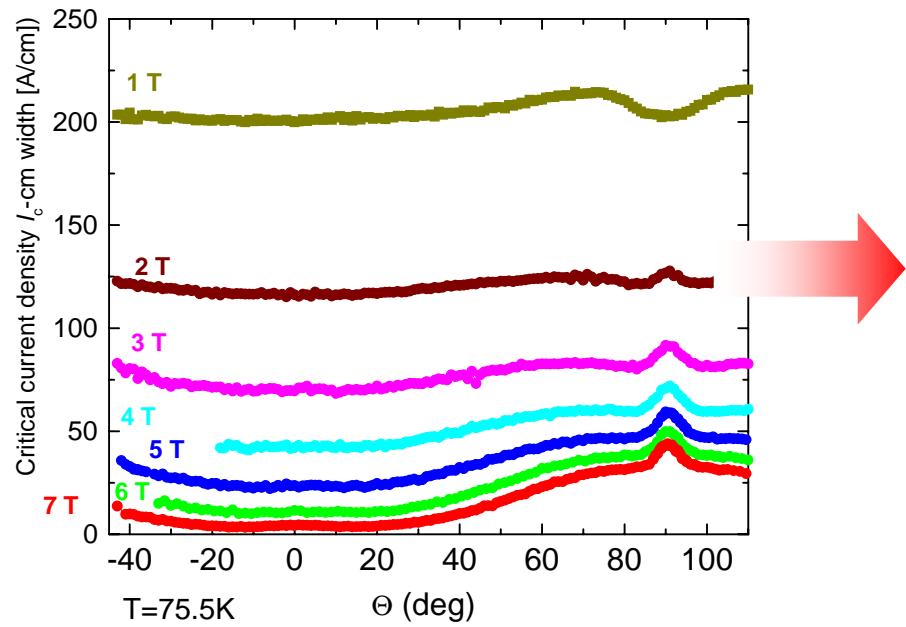
Los Alamos
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LANL, PLD film

✓ Strong isotropic transport observed independently

Blatter scaling of angular J_c dependence of BNL 3 μm sample

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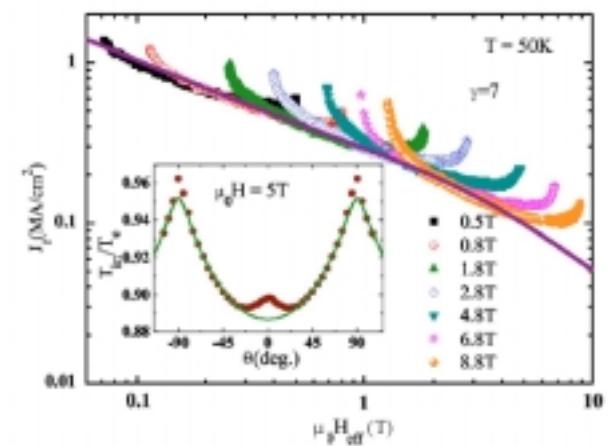
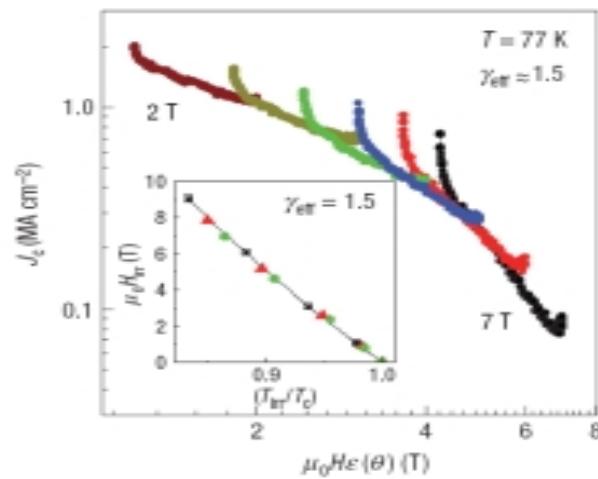
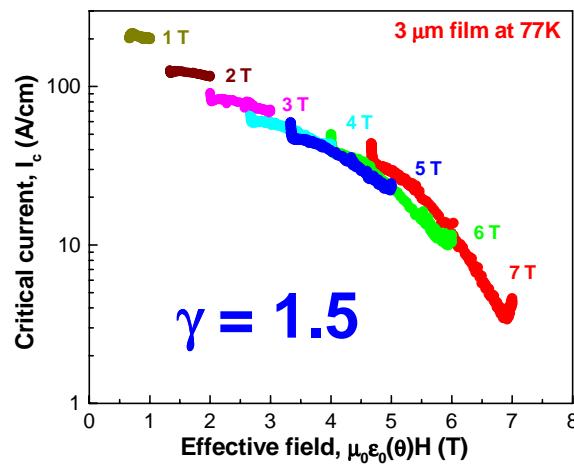


$$H_{\text{eff}} = H^* (\sin(\theta)^2 + \cos(\theta)^2 / \gamma^2)^{1/2} \quad (\text{Blatter et al. PRL 1992})$$

✓ $\gamma \approx 1.5$ provides the best fit, not $\gamma \approx 5$ for “classic” YBCO

Application of Blatter scaling to different samples

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BNL, SST 2007
 $\gamma = 1.5, T_c = 92.5 \text{ K}$

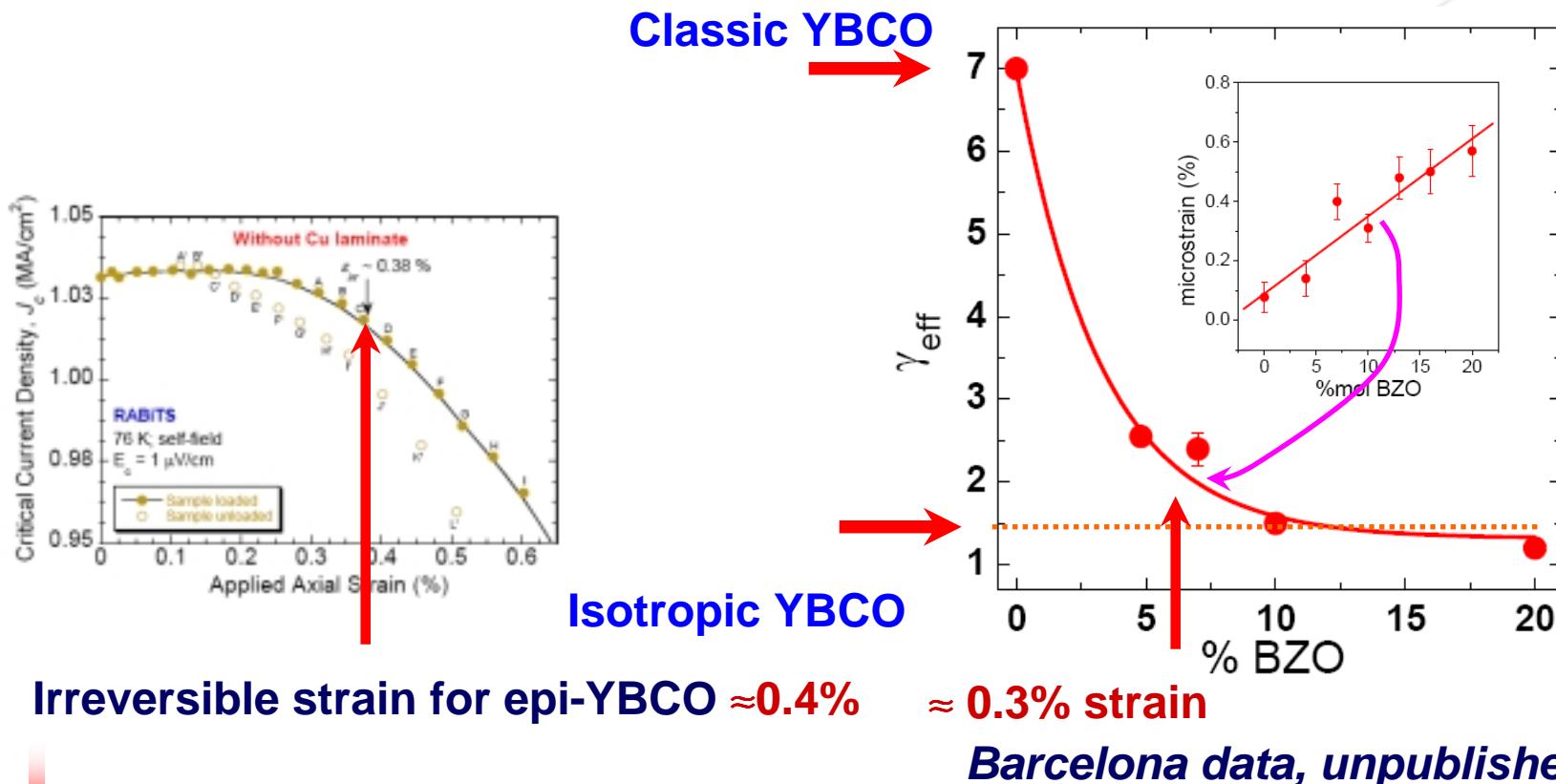
Barcelona, Nat. Mat. 2007
 $\gamma = 1.5, T_c = 91 \text{ K}$

PLD film $\gamma = 7$
 $\gamma = 7, T_c = 86-87 \text{ K}$

✓ Is $\gamma = 1.5$ a universal value?

Why does this happen? Critical strain hypothesis

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- ✓ As we exceed 0.3% (001) strain we have $\gamma 7 \Rightarrow 1.5$ transition

Implications

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- **Unique features of isotropic YBCO**
 - Resilience to thermal de-pinning
 - Strong current retention in high fields
- **Can we re-visit Bi-2223 and make it isotropic?**
- **Is strained meta-stable structure an explanation?**
- **Does the mass anisotropy really change?**
 - Does the penetration depth becomes isotropic?
 - Normal state resistivity?